GNSS Reflectometry: Recent activities at GFZ and selected international projects

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Title

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Abstract

During the last decade GPS remote sensing techniques for ground and space based atmospheric sounding were established. Such methods use atmospheric GNSS propagation errors as signals to derive information on atmospheric temperature, water vapor or electron density. Ground based, airborne, and satellite measurements can be used to derive this information from regional (local) up to global scale. GNSS based atmospheric sounding data are accepted by atmospheric scientists and weather researcher and are operationally used to improve numerical weathers forecasts and are the based for numerous climatological studies to characterize climate change.

Another GNSS remote sensing technique is based on the analysis of GPS signals, reflected from water and ice surfaces, which can be used to derive properties of these surfaces, as, e.g., altitude information or wave heights. Such techniques are currently in focus of international research and regarded to have a similar potential for a broad spectrum of scientific and operational applications as the atmosphere sounding techniques. The goal of the contribution is to introduce GFZ activities in reflectometry and to briefly review the current status.

GNSS reflectometry at GFZ was initiated by the analysis of space based reflectometry signals, recorded at the German satellite CHAMP with the very successful GPS radio occultation experiment at this satellite, which was under lead of GFZ. It was followed by a series of ground-based experiments using open GPS single frequency but also modified commercial dual frequency GNSS receivers in mountainous and coastal regions to derive lake surface

altitudes. Also initial results for the derivation of surface properties, as wave heights, were derived.

The spectrum of activities was extended within a large German research project GITEWS (German Indonesian Tsunami Early Warning). Part of the project was investigations related to the potential use of GNSS reflectometry for the application in future satellite based Tsunami early warning systems.

Therefore the spectrum of reflectometry activities was extended to flying platforms, as the airship Zeppelin and the new German research aircraft HALO (High Altitude and LOng Range) to focus the challenge, which brings the use of moving platforms for the analysis of GNSS reflectometry data. Also the application of GNSS reflectometry aboard space platforms (in parallel with GNSS radio occultation), as small satellites or the International Space Station (ISS) is under investigation within several scientific studies in cooperation with industry and scientific partners. Examples for these studies/proposals are several small satellite studies in cooperation with regional partners and the GEROS proposal. GEROS stands for, GNSS REflectometry, Radio Occultation and Scatterometry onboard ISS for long-term monitoring of climate observables using innovative space geodetic techniques onboard the ISS. GEROS was proposed in response to the European Space Agency Research Announcement for ISS Experiments relevant to study of Global Climate Change by an international team under lead of GFZ.

In the recent months also activities related to flood monitoring using GNSS reflectometry within a research project in Mekong-Delta (Vietnam) was started and another project related to GNSS based soil moisture monitoring was successfully attracted foreseen to be started in late 2012.

The broad spectrum of the GFZ reflectometry activities only can be managed within a broad cooperation network with numerous international partners.

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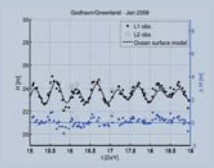
Introduction

GNSS reflectometry (GNSS-R) at GFZ was initiated by the analysis of space based reflectometry signals, recorded at the German satellite CHAMP as part of its very successful GPS radio occultation experiment (Beyerle et al., 2002). Stimulated by these results several scientific activities related to the development of GNSS reflectometry with international partners were started. The main goal is to deploy a powerful and innovative remote sensing tool for Earth Observation at different spatial scales with international partners.

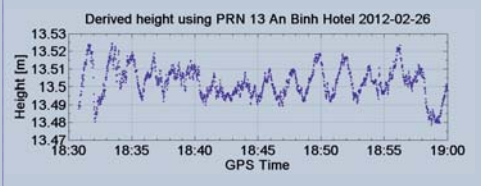
GROUND STATIONS

Tides at Greenland



A GNSS antenna was installed 600 m above the sea surface at Disko Bay (Greenland, Fig.). GNSS reflectometry was used to monitor the tides in the bay (Fig.) with dm accuracy (Semmling et al., 2011).

Flood monitoring at Vietnam



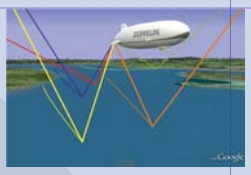
GNSS reflectometry equipment was installed 12 and 20 m above the Mekong River Delta at Vietnam as part of the United Nations WISDOM research project (see talk Beckheinrich et al.). The measurements were sucessfully analyzed to monitor variations of the river surface (Fig.).

Soil Moisture

A recent 3year research project will be started in early 2013 (young scientist position announced at GFZ). The main goal will be the derivation of soil moisture parameters using GNSS reflectometry at test sites in North-East Germany (e.g., Larsen et al., 2008).

FLIGHT PLATFORMS

Zeppelin

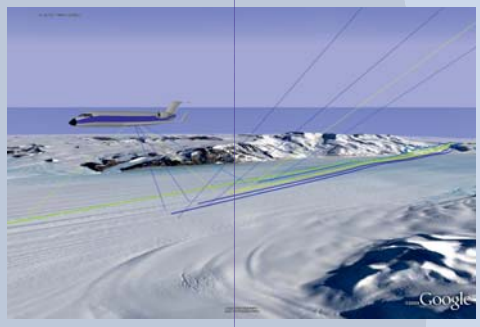


To increase the spatial scale of GNSS reflectometry a slowly flying platform was chosen: a Zeppelin airship. After a long preparation period, a measurement campaing over the Bodensee lake, southern of Germany, was successfully achived with three measurements flights (see poster Semmling et al.)

GEOHALO

GEOHALO was the first flight experiment with the new German research aircraft HALO in June 2012. A GNSS remote sensing experiment was successfully performed as part of GEOHALO (see poster Semmling et al.).

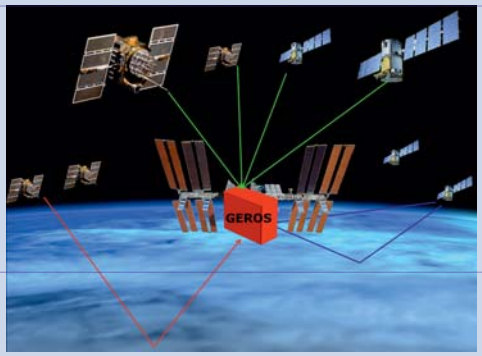
ANTHALO



A vision of GFZ scientists is GNSS-R based remote sensing with HALO at Antarctica. A corresponsing research proposal was postponed to a later phase of the HALO missions (Wickert et al., 2010).

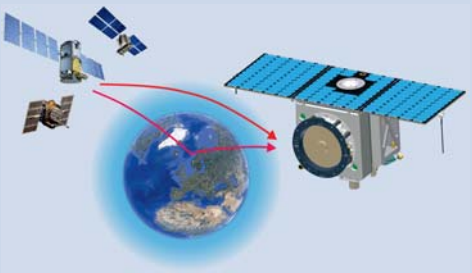
SPACE PLATFORMS

International Space Station ISS



GEROS-ISS (GNSS REflectometry Radio Occultation and Scatterometry aboard ISS) is a recent international proposal (Wickert et al., 2012) submitted within ESA Research Announcement for ISS Experiments relevant to study of Global Climate Change. GEROS-ISS won this call, as the only recommended mission. Funding of a phase A study is expected.

Small Satellites



Several small satellite studies (MicroGEM, NanoGEM, NanoX) were finished in 2010-2012 (Fig. **Nano G**NSS **E**arth **M**onitoring). The main goal the is realization of a prototype satellite for GNSS reflectometry and occultation. Behind this, stands the idea for a small satellite constellation for GNSS Earth Monitoring (see e.g., Stosius et al., 2011).

GRACE Follow On (FO) mission

The U.S./German GRACE-FO mission is currently foreseen for launch in 2017 and the successor of the extremly successful gravity mission GRACE. An experiment for coherent reflectometry was proposed by scientists from GFZ.

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